CHAPTER 11

PRACTICE EXERCISES

SECTION I MULTIPLE CHOICE

Questions 1–3

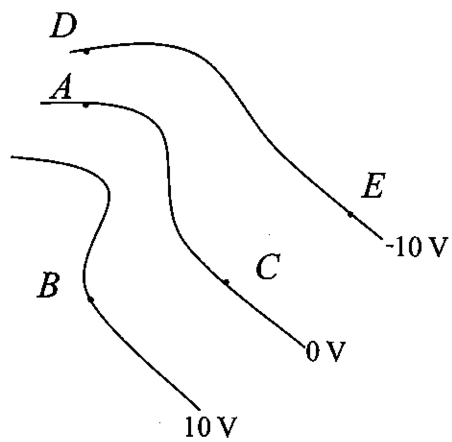

Figure 9

1. The direction of the electric field at A is

   (A) → (B) ↑ (C) ↓ (D) ↗ (E) ↙

2. An electron placed at C and released would most likely pass closest to

   (A) A (B) B (C) C (D) D (E) E

3. The distance between D and A is 10^{-2} m. The strength of the electric field at A is most nearly

   (A) $10 \frac{\text{V}}{\text{m}}$ (B) $10^{2} \frac{\text{V}}{\text{m}}$ (C) $10^{-1} \frac{\text{V}}{\text{m}}$ (D) $10^{3} \frac{\text{V}}{\text{m}}$ (E) $10^{-2} \frac{\text{V}}{\text{m}}$

4. A positive charge Q is a distance R from a point P. The electric potential at P could be doubled by
   I. placing an identical charge Q at another point a distance R from P
   II. placing charge $2Q$ at a distance $2R$ from P
   III. placing charge $4Q$ at a distance $2R$ from P

   (A) I only (B) II only (C) III only (D) I and II only (E) I and III only

Questions 5 and 6
Two equal positive charges are fixed on the x-axis equal distances from the origin.

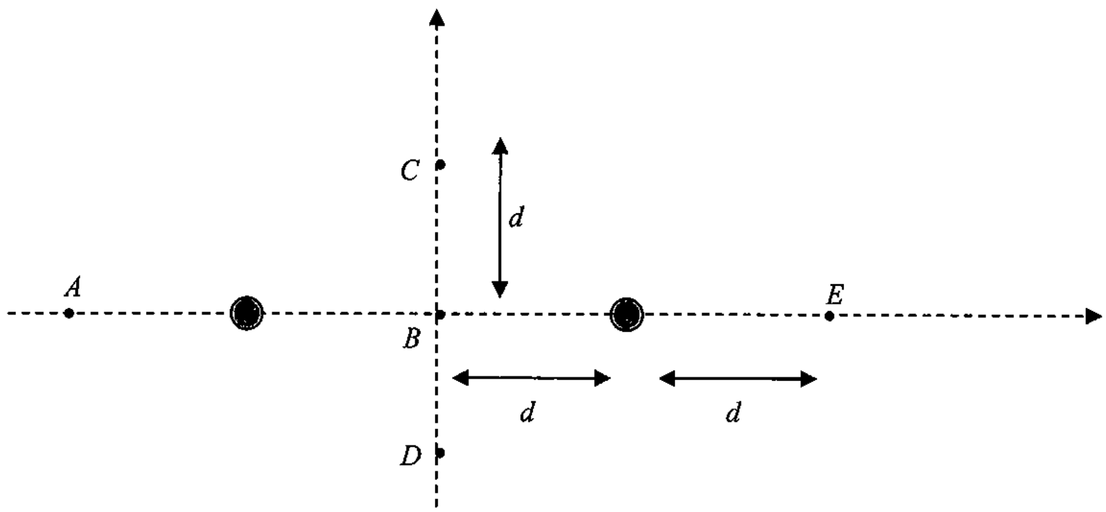

Figure 10

5. The electric potential is a maximum at

(A) A (B) B (C) C (D) D (E) E

6. It would take 0 work to move a charge from

(A) A to B (B) C to B (C) B to D (D) A to E (E) C to E

7. An isolated conductor has a charge Q placed on it. When equilibrium is established,

(A) excess charge will reside on the surface, and the electric field will be 0 outside the conductor
(B) the charge will spread throughout the conducting material, making the electric field 0 inside the conductor
(C) all points of the conductor will be at the same potential, with electric field lines tangential to the surface
(D) the excess charge will move to the surface, and all points of the conductor will be at the same potential
(E) the excess charge will move to the surface, making the electric field inside the conductor equal to the field just outside the conductor

PRACTICE EXERCISES

SECTION II FREE RESPONSE

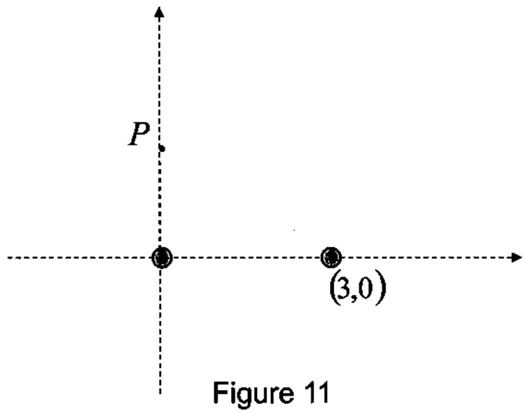

Figure 11

1. Two identical + 6 μC charges with mass 10^{-6} kg are placed as shown in figure 11.

   (a) Determine the electric potential at P, with position (0, 3).
   (b) An identical third charge is brought slowly from far away to P. How much work did this take?
   (c) The third charge is then released. Calculate the maximum speed it will retain.

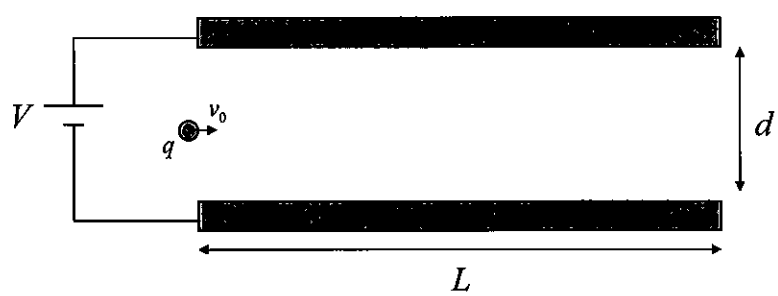

Figure 12

2. Two identical square conducting plates of side L are separated by a distance d. They are connected to a battery that maintains a potential difference V between the plates. A charge q, with mass m, moving parallel to the plates (figure 12), enters the region midway between the plates with speed v_0 and is deflected so that it just misses the top plate as it leaves the region. Express your answers to the following in terms of d, V, q, m, and v_0.

   (a) Determine the magnitude and direction of the nearly uniform electric field in the region between the plates.
   (b) What is the sign of the charge q?
   (c) Determine the speed of the charge as it exits the region between the plates.
   (d) Determine the length L of the plates.

Answers and Explanations

MULTIPLE CHOICE

1. The answer is B. The electric field is perpendicular to the equipotentials, pointing toward lower potential.

2. The answer is B. Electrons are negative and will move toward higher potential, which would take the electron from 0 V toward the +10 V surface.

3. The answer is D. The average field in the region between A and D is $E = \frac{\Delta V}{s} = \frac{10}{10^{-2}}$

4. The answer is D. For several point charges, just add the contribution of each. The contribution from I is $k\frac{Q}{R}$, the same as the original, so the potential is doubled. The contribution from II is also the same. Number III, however, gives $k\frac{4Q}{2R}$, which is twice the original.

5. The answer is B. At any point, the two charges contribute $V = k(\frac{q}{r_1} + \frac{q}{r_2})$. By making r_1 and r_2 as small as possible, simultaneously you get the biggest value of V. This occurs at B.

6. The answer is D. A and E are both at the potential $V = k(\frac{q}{R} + \frac{q}{3R})$, so there's no potential difference between the two points. This means it takes no net work to move a charge between the points. Notice that C and D are also at the same potential, but they weren't a choice.

7. The answer is D. In electrostatic equilibrium, excess charge on a conductor lies on the surface. Since the field is 0 inside and enters at right angles at the surface, it takes no work to move a charge anywhere on or in the conductor, so the entire object is at the same potential.

FREE RESPONSE

1. (a) Superpositions allows you to add the potentials of each charge as if the other weren't present.

$$V_P = 9 \times 10^9(\frac{6 \times 10^{-6}}{3} + \frac{6 \times 10^{-6}}{3\sqrt{2}}) = 3.1 \times 10^4 \text{V}$$

(b) The work follows from the definition of electric potential.

$$W = qV_P = (6 \times 10^{-6})(3.1 \times 10^4) = 0.19 \text{ J}$$

(c) When the third charge is brought in to point P, it has increased in PE by an amount equal to the work done in bringing it in, 0.19 J. When it is released, the maximum speed attained will occur when this PE is lost and converted into KE.

$$0.19 = \frac{1}{2}mv^2 = \frac{1}{2}(10^{-6})v^2$$

$$v = 616\frac{\text{m}}{\text{s}}$$

2. (a) From the battery orientation, the top plate is at higher potential, so the field points down between the plates. The magnitude of the uniform field is $E = \frac{V}{d}$.

(b) Since the charge was attracted to the top plate where the potential was higher, it must be negative.

(c) Use the work-energy theorem. The electric force did positive work.

$$W_{\text{electric}} = \Delta K$$

$$|q|(\tfrac{V}{2}) = \tfrac{1}{2}mv^2 - \tfrac{1}{2}mv_0^2 \;\text{C}\; v = \sqrt{v_0^2 + \tfrac{|q|V}{m}}$$

(d) Since $v = \sqrt{v_0^2 + v_y^2}$, it follows from (c) that $v_y = \sqrt{\frac{|q|V}{m}}$.

The acceleration of the charge has only a *y*-component and is determined from Newton's Second Law.

$$a_y = \frac{qE}{m} = \frac{qv}{md}$$

The first motion equation will give you the time between the plates.

$$v_y = v_{y0} + at = 0 + \frac{qV}{md}t$$

$$\sqrt{\frac{|q|V}{m}} = \frac{|q|V}{md}\;\text{C}t = d\sqrt{\frac{m}{|q|V}}$$

Finally the horizontal distance traveled depends only on the initial horizontal speed v_0.

$$L = v_0 t = v_0 d\sqrt{\frac{m}{|q|V}}$$